U.S. DEPARTMENT OF ENERGY | Office of ENERGY EFFICIENCY & RENEWABLE ENERGY
SOLAR ENERGY TECHNOLOGIES OFFICE

2020 SETO PEER REVIEW

Desalination and Other Industrial Processes

Peer Review 2020

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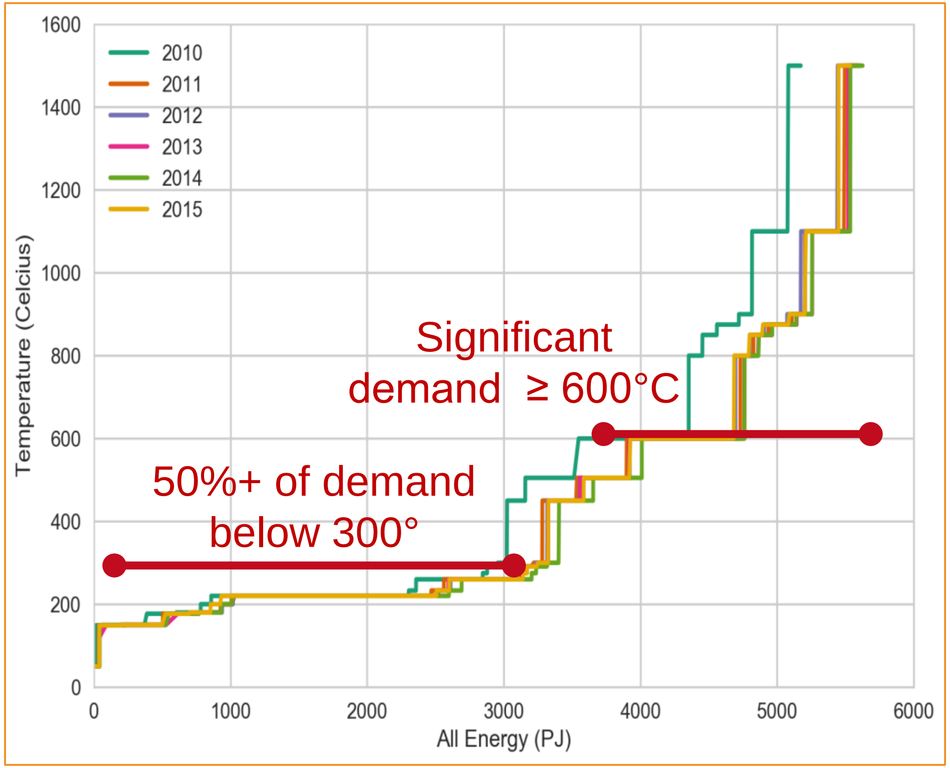
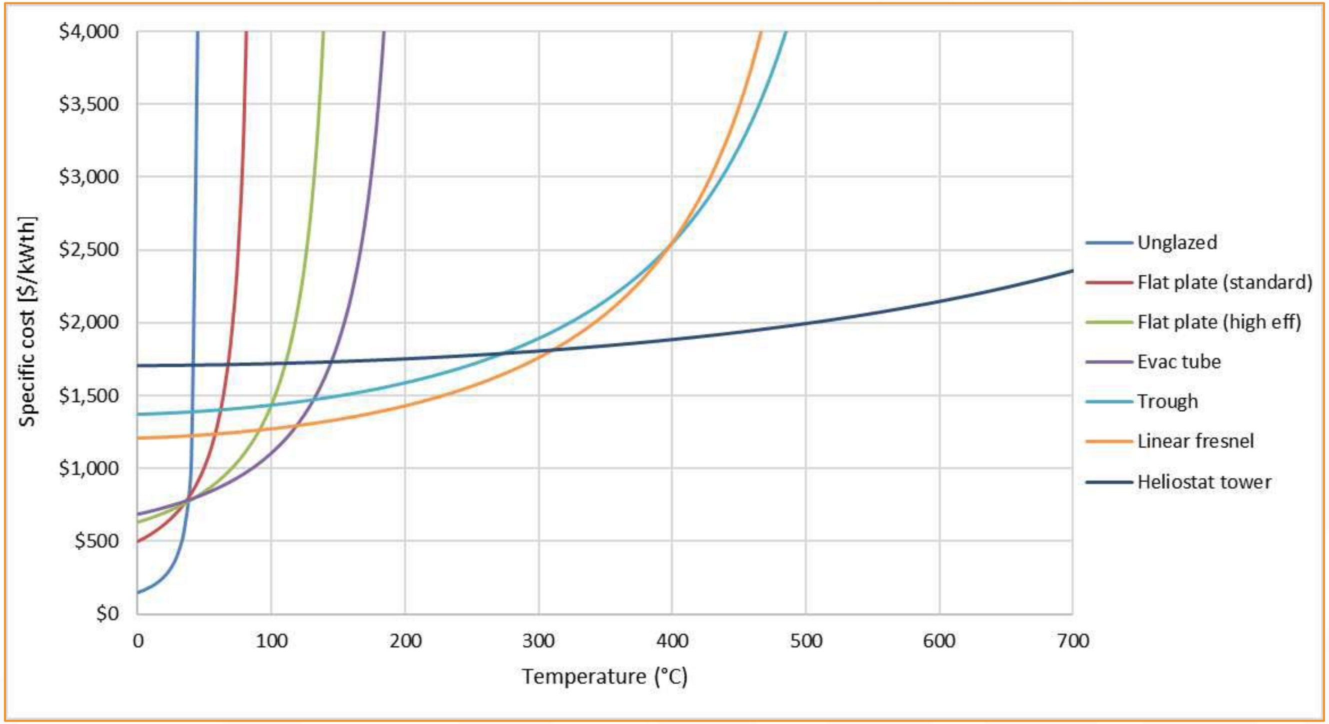
Industrial Processes Require a Wide-Range of Temps

- Industrial processes range from those requiring hot water at 70°C to those melting steel scrap at 1,800°C
- Select industrial players could be prime targets for technology adoption and demonstration
- Funded initial IPH analysis on the potential for SIPH in CA
  - NREL Report: "Initial Investigation into the Potential of CSP Industrial Process Heat for the Southwest United States", 2015



Energy demand by process temperature
(Sources: McMillan and Ruth 2019, NREL DOE Report # 34454)

But Solar Thermal Costs and Performance Vary Strongly with Temperature



Renewable Energy Options for Industrial Process Heat (ARENA Report, Nov 2019)

Our first major effort to support IPH – Desalination FOA (2017)

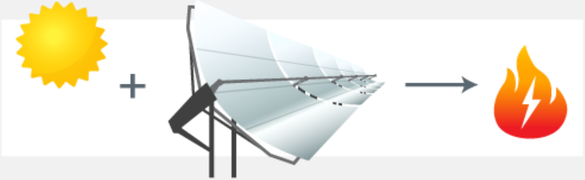
$$LCOW(\$/\text{m}^3) = \frac{\text{Total lifetime costs (capital,financial,O\&M)}}{\text{Total lifetime clean water generation}} \; ; \quad LCOH(\$/\text{kWhth}) = \frac{\text{Total lifetime costs (capital,financial,O\&M)}}{\text{Total lifetime thermal generation}}$$

TOPIC AREA 1: Innovations in thermal desalination technologies

7 projects

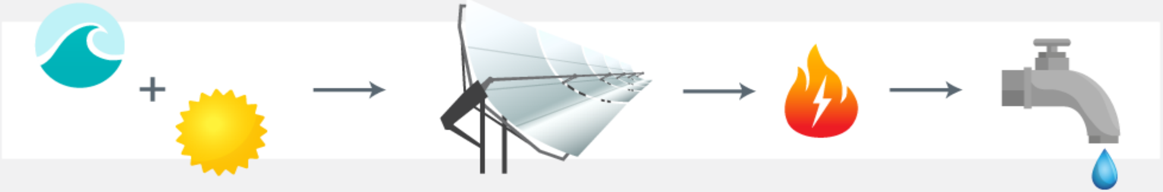
TOPIC AREA 2: Low-cost solar thermal heat

4 projects



TOPIC AREA 3: Integrated solar desalination systems

2 projects

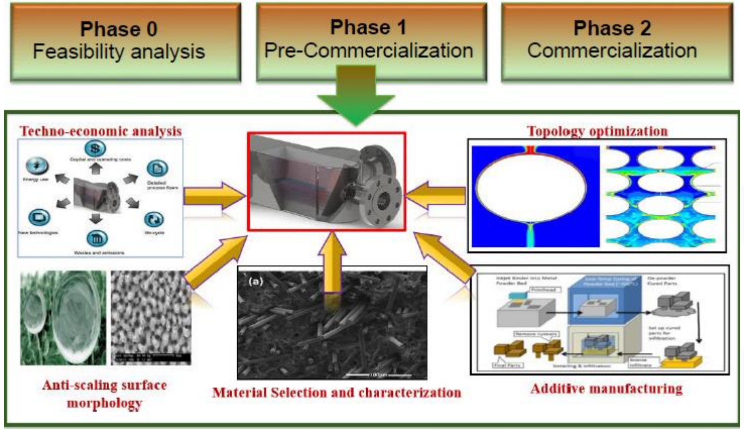


TOPIC AREA 4: Analysis for solar thermal desalination

1 project

Projects included innovative Thermal Desalination Technologies

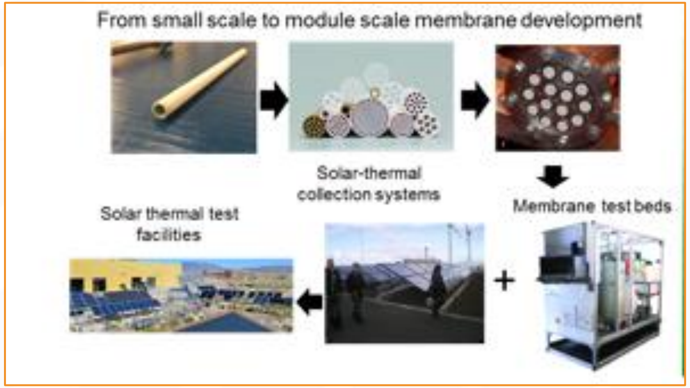
Topic 1



Ultra-compact and efficient heat exchanger for solar desalination with unprecedented scaling resistance

Use additive manufacturing to create geometrically optimal heat exchangers, and with judicious use of filled and unfilled polymers and metals, they create ultra-compact, efficient heat exchangers highly resistant to fouling and corrosion.

Topic 1

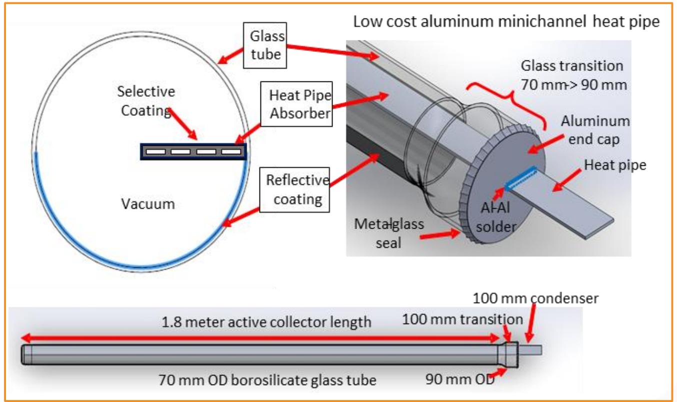


Ceramic Membrane Distillation addresses challenges like mass and heat transfer, wetting, scaling and fouling

Membranes are first designed and optimized at small scale before scaling up and testing with a solar thermal test bed. MD technology offers an alternative to RO for high recovery oh highly saline feeds and enables the possibility of ZLD. Ceramic materials enable this by providing a more robust platform for concentrating brines of extreme temperature of chemistry.

And Integrated Collectors with Storage

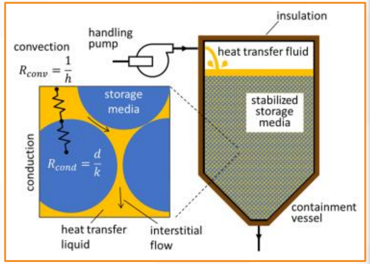
Topic 2



ICPC with low-cost heat pipe and vacuum tube with integrated optics

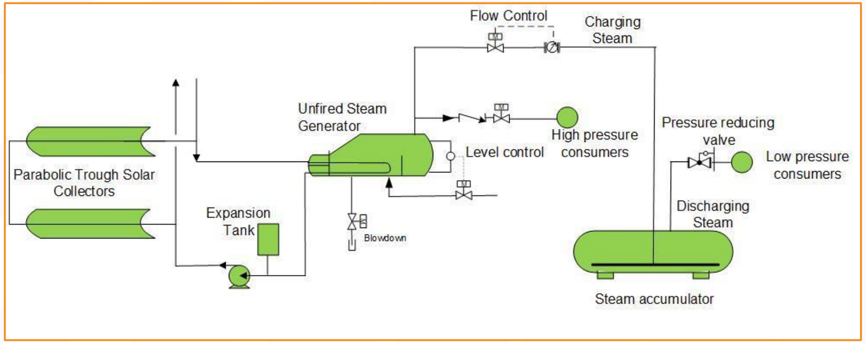
20 kW_{th} array charges thermal storage by 90 kWh_{th} over 6 hours while simultaneously providing 5 kW_{th} at 120°C in usable energy.

TES provides a consistent 5 kW_{th} at 120°C discharged over 18 hours
Final system demonstrates the attainment of a LCOH ≤ $0.015/kWh.



Topic 2

SUNVAPOR
RENEWABLE PROCESS HEAT



Solar Steam on Demand

Steam is stored by transferring its heat through condensation to a pool of subcooled water, thereby raising the temperature of the water. When there is a demand for steam from the accumulator, the pressure is lowered and steam is evaporated ("flashed") from the heated water.

Portfolio also includes demonstration and analytical projects

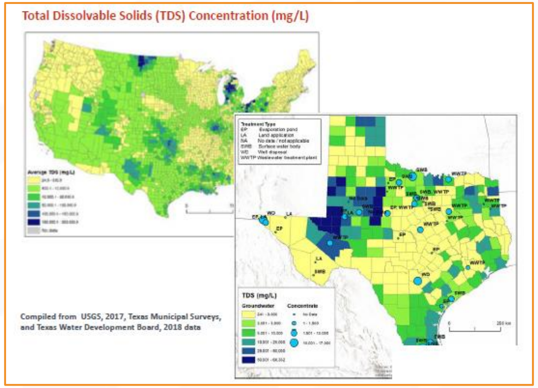
Topic 3

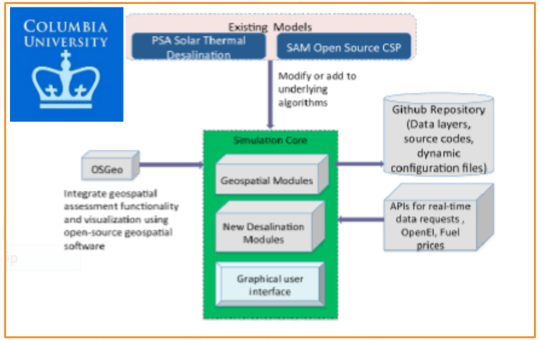
Hawaii Ocean Science & Technology Park
Administered by the Natural Energy Laboratory of Hawaii Authority

Hawaii Solar Desalination Project

Project advances the techno-economic viability of solar powered Forward Osmosis (FO). Will demonstrate cost effective desalination of sea water using a FO system employing State of the Art polymeric FO membranes.

Topic 4



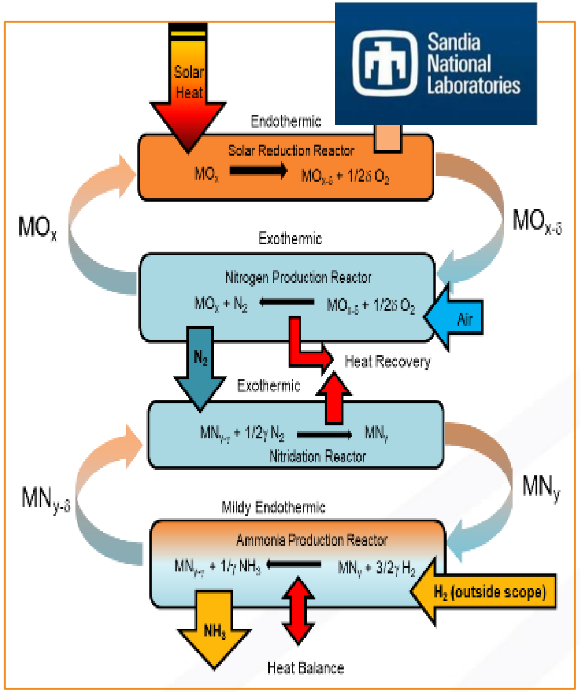


GIS-based GUI Tool for analyzing solar thermal desalination systems and high-potential implementation regions

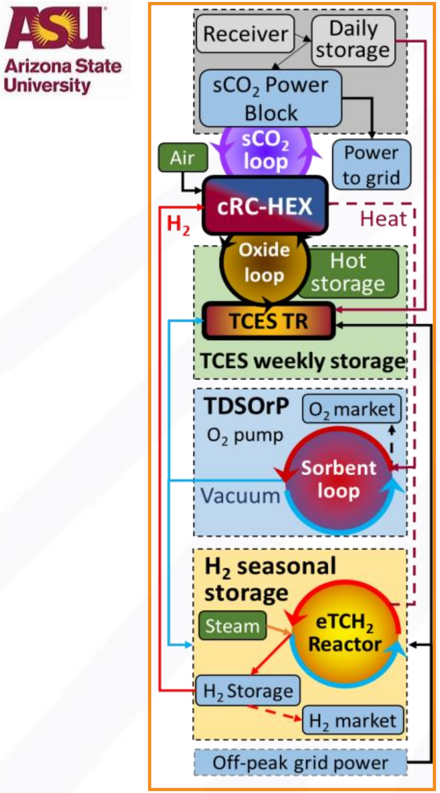
Tool uses geospatial analysis in combination with energy and desalination technology modeling framework for current and emerging desalination processes on industrial scales. It will facilitate: (i) streamlined identification of high-potential regions where solar thermal desalination can be most competitive and (ii) integrated system-level simulation and optimization.

Additional Opportunities exist for High Temperature IPH

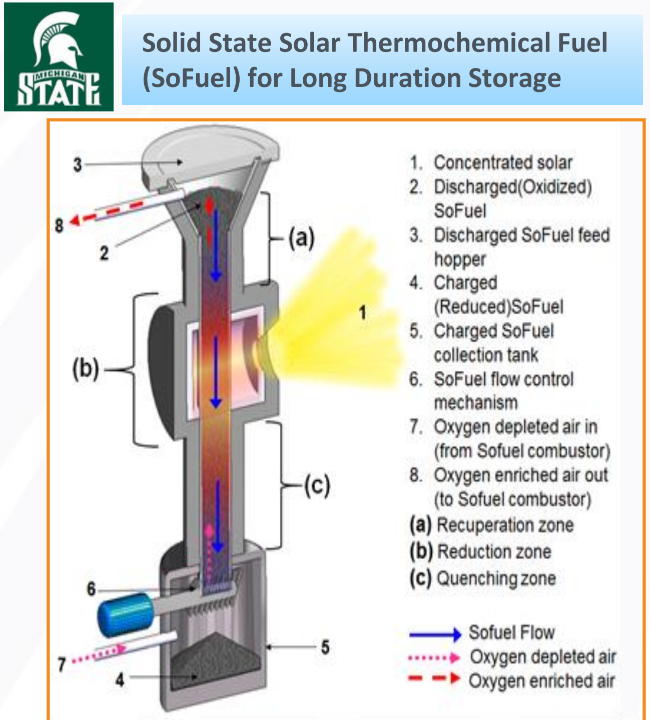
Solar-Thermal Ammonia Production (STAP)



Economic Weekly and Seasonal Thermochemical and Chemical Energy Storage for Advanced Power Cycles



Solid State Solar Thermochemical Fuel (SoFuel) for Long Duration Storage



Layout of a SoFuel CSP production plant

So, what is next?

Continue to refine our understanding of and strategy for Concentrating Solar Thermal projects and their impact on IPH

1. Will continue to support projects that span high and low temperature domains
2. Will continue to support innovative technologies and also reducing the cost of current technologies

Two impactful Solar IPH strategies:*

1. As an add-on to existing processes to provide fuel savings
2. As part of a broader process modification strategy to drastically reduce fuel use (e.g. linked with storage, efficiency, etc.)

*Internal NREL DOE Report

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